

Master of Information Technology and Analytics (MITA) Program

Course:	Optimization Modeling for Business Analytics 22:544:648:91
Term:	Spring 2023
Class Times:	Online asynchronous remote class
Classroom:	N/A
Instructor:	Dr. János D. Pintér, MSIS Department
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Office hours:	Tuesday 5:00-6:00 pm

PREREQUISITES AND EXPECTED BACKGROUND

Adequate (college-level) knowledge of algebra, calculus, probability, statistics. Topical courses are *Operations Management* (33:136:386), and *Introductory Statistics for Business* (01:960:285). Decision modeling and computer programming skills are further useful assets: topical courses are *Business Decision Analytics under Uncertainty* (33:136:400), and *Foundations of Business Programming* (33:136:388).

SUMMARY COURSE DESCRIPTION

Business Analytics (BA) refers to the concepts, technologies, and practices used to analyze and to manage business data, information, and performance. Business Analytics helps the understanding and solution of important issues arising in business organizations, and in a broad societal context. The insights gained by applying BA assist the management and use of information, as well as the development of strategic, tactical, and operational level decisions.

Within the context of BA, the ability to develop quantitative (descriptive and prescriptive) models, to solve such models with appropriately chosen software tools, and to interpret the results obtained is a competitive advantage. Modeling and solving real-world decision problems requires modeling insight and the actionable knowledge of numerical solution techniques. Professional and communication skills are essential to interpret the results obtained.

This course is focused on developing and practicing the skillset outlined above. We will discuss the key mathematical concepts of decision model development, the choice of appropriate model types to handle a broad variety of optimization problems, the challenges of solving such models, and the analysis and interpretation of the results. The discussion will be illustrated by a range of application examples.

We will introduce and use state-of-the-art optimization (solver) engines available within an integrated optimization model development and solver environment. We review the key concepts regarding how these solvers operate, and discuss the answers and performance expected from solver engines. While focusing on the use of a specific modeling environment, we will highlight several alternative software environments.

LEARNING OBJECTIVES

Course attendees will acquire the following skills.

- Learn about optimization modeling techniques to formulate various decision problems
- Select appropriate models for specific problem-types
- Formulate optimization models expressed in mathematical notation
- Translate mathematical optimization models to a computer-based modeling environment
- Understand the choice of appropriate solver engines and their expected performance
- Analyze and interpret the solution of optimization problems in their real-world context
- Recognize existing and potential applications of optimization

READING MATERIALS AND SOFTWARE

Textbook

Frederick Hillier and Gerald Lieberman, *Introduction to Operations Research* (11th Edition). ISBN10: 1259872998, ISBN13: 9781259872990, McGraw Hill, 2021.

<https://www.mheducation.com/highered/product/introduction-operations-research-hillier-lieberman/M9781259872990.html>.

This well-received textbook offers a combination of theoretical foundations of BA, with practical insights and real-world examples. The course will cover selected topics and chapters from this book. The use of earlier textbook editions is also possible. Make sure to familiarize with materials from the current textbook edition, considering related discussions, examples and exercises in coursework.

Software

A broad range of software systems can be put to good use in the context of BA. Here we focus on the modeling and solution of optimization problems. Course attendees will develop model development and optimization skills through hands-on exercises. We will use the prominent modeling language AMPL, with its solver options. AMPL is described by its developers in the following book:

Robert Fourer, David M. Gay and Brian W. Kernighan, *AMPL: A Modeling Language for Mathematical Programming* (2nd Edition). Duxbury-Thomson, 2003. ISBN-13: 978-0534388096, ISBN-10: 0534388094.

<https://www.amazon.com/AMPL-Modeling-Language-Mathematical-Programming/dp/0534388094>

An online version of this book is available at www.ampl.com. The AMPL software is also freely available for Linux, MacOS, and Windows platforms at www.ampl.com for educational purposes, to handle size-limited models. (There also other licensing options described at the AMPL website.) AMPL supports calls to external productivity tools, including databases, spreadsheets, and visualization. The AMPL website offers further resources, including all model examples discussed in the AMPL book.

In addition to AMPL (as needed), we will use Excel to prototype and to illustrate certain decision models.

At your discretion, you can also use other model development and computing systems such as AIMMS, Excel, GAMS, Julia, LINGO, Maple, Mathematica, MATLAB, MPL, Python, R, SAS, etc. in your independent studies, including work on assignments and projects. However, it is clearly your personal decision and responsibility to learn how to use optionally these alternative software products. Familiarity with these or similar tools can become useful in other courses, and in your working career. Some of the software products listed above also have free educational versions.

COURSE SCHEDULE

The course outline is presented below. Course topics will be based on selected portions of the textbooks referred to above, including the discussion of AMPL (and, as needed, Excel) model examples. Please note that it may be necessary to deviate from this schedule if unforeseen circumstances arise, and your instructor reserves the right to introduce reasonable changes. The actual schedule will also depend on the course attendees' background knowledge.

Class	Topic	Readings from Course Textbook
1-2	Decision-making and Optimization Review	H&L, Chapters 1, 2
3-5	Linear Algebra Review: Vectors and Matrices Calculus Review: Convexity, Classical Optimization Methods Model Relaxations, Model Analysis and Preprocessing	H&L, Appendices 2 to 4 Lecture notes by instructor
6-7	The AMPL Model Development Environment	AMPL book, Chapters 1 to 5
8-10	Linear Optimization with Continuous Decision Variables	H&L, Chapters 3 to 5
11-13	Graphs and Networks	H&L, Chapters 9, 10
14	Review for Midterm Exam	All materials covered so far
15	Midterm Exam	All materials covered so far
16-18	Integer Linear Optimization	H&L, Chapter 12
19-22	Nonlinear Optimization: Convex and Non-convex Models Exact and Heuristic Solution Methods	H&L, Chapters 13, 14 Lecture notes by instructor
23-25	Stochastic Optimization and Simulation	H&L, Chapters 7, 20
26	Multi-criteria Optimization	Lecture notes by instructor
27-28	Review for Final Exam Final Exam: time and place TBA	All materials covered All course materials covered

COURSE DELIVERY AND TECHNOLOGY

The course can be taught using both in-person and online delivery modes as/if requested by Rutgers University. The discussion of topics will be based on PowerPoint presentation slides and on hands-on examples: these materials will be made available to all course attendees.

We will use the Canvas course management system, <https://canvas.rutgers.edu>.

Office hours will be held using the “Zoom” option of the Canvas site for the course.

Presentation slides and software examples: following each class, PDF versions of the presentation slides will be posted, together with the examples discussed. These files will appear in topical modules on the Canvas course page. Please allow up to a day to post the slides after the corresponding lecture presentation: this way, possible student feedback can be incorporated.

Lecture recordings: we plan to record all classes so that all students can watch them also later. Links to lecture recordings will be accessible on Canvas by selecting the “Zoom” option for the course, and then the “Cloud recordings” tab.

Software: Microsoft Excel, with add-ins such as the Excel Solver, and other analytical tools as needed.

Class announcements will be posted in the “Announcements” panel on the Canvas course site. Please make sure to follow these announcements.

All assignments will be posted and collected electronically in Canvas. All materials submitted by students are expected to be professionally formatted electronic documents (such as Word files) and computer files (such as Excel files). Exams will be administered through Canvas, in a similar fashion.

OFFICE HOURS AND COURSE RELATED QUESTIONS

Regular office hours will be held throughout the semester as shown on page 1 of the syllabus, except during semester breaks. Office hours will be held by using Zoom, with the meeting links available in the “Zoom” option of the Canvas site for the course. I will be glad to talk and to help all students on a “first come, first serve” basis. All are welcome to attend these discussions. Office hours could be subject to change, depending on student and instructor schedules, and perhaps on other unforeseeable factors.

Please do not use office hour time to try to catch up on missed classes. Furthermore, please do not simply show me a draft or final version of your homework assignment and ask me to check whether your answers are correct. Instead, please ask specific questions about points about which you are unsure, before submitting your work.

You can also send me e-mails with course related questions, especially if you are unable to attend scheduled office hours (with a valid reason). Please send all emails to my Rutgers email address, as opposed to sending messages on Canvas.

I reserve the right to post answers to all course related questions received, if these questions and answers are of interest also for other students.

GENERAL CONDUCT

Behaviors that negatively affect the atmosphere of the course (whether arising in the classroom, in email communications, or during online discussions) are not acceptable. Please maintain civility, respect and politeness in all communications with each other and with your instructor.

During our joint classroom work and in sessions, all cellphones should be stowed in silence mode. Distracting side discussions should be avoided: please ask questions as needed, for the benefit of all attendees.

ACADEMIC INTEGRITY

Integrity is the quality of having strong moral principles, and to live a life that is consistent with these principles. Integrity involves doing the right thing, and it also involves not doing the wrong thing. In plain language, in an academic environment integrity requires honest individual and independent work effort from all course attendees, without any form of misbehavior. Notable examples of misbehavior are cheating on assignments and exams, by copying other people's work, or by using resources without properly crediting these.

Integrity is a key component of academic and professional success. Every student is personally responsible for understanding and practicing these principles. If the stated course and exam policies are violated by someone, then these violations are considered against Rutgers University's Academic Integrity Policy.

For further details, please consult <https://myrbs.business.rutgers.edu/academic-integrity>.

ATTENDANCE, CLASS CANCELLATION AND EMERGENCY POLICIES

In-person courses: all registered students are expected to attend classes and to actively participate. Regardless of in-person, online, or hybrid course delivery, all students are expected to follow the course materials diligently and on time, in order to avoid falling behind with coursework. It is much better and easier to work consistently and steadily, than trying to catch up.

Class cancellations are unlikely without a substantial reason. In the event of possible disruptive events (university-wide health concerns and regulations, severe weather conditions) that affect normal coursework, Rutgers University and your instructor will make every effort to communicate pertinent information to all course attendees. If the university cancels classes for some reason, then we will conform to such decisions.

Please check <https://www.rutgers.edu/status> for up-to-date operating information. You can sign up for emergency text messages at <https://personalinfo.rutgers.edu/pi/updateEns.htm>.

ASSIGNMENTS AND EXAMS

Assignments

As planned, homework assignments will be posted by semester week Fridays (once biweekly), except for the classes immediately preceding exams. The number of assignments will be five (5): this may be changed (at my discretion if deemed necessary), and communicated in time to all attendees. Assignments will be

due one week after posting, except when a semester break intervenes: in such cases students will get an extra week for submission. Homework assignments must be submitted using Canvas by 11:59 pm on the due date, unless stated otherwise: do not send homeworks by email. Homework submitted late (for a valid reason) may be accepted at my discretion, possibly subject to a lateness penalty. Late homeworks will not be accepted after the solution is posted.

Collaboration and discussions in small student groups are permitted on homework assignments. Working in small groups can often help learning. However, you should always hand in your own individual assignment (without copying someone else's work), and take full responsibility for its content.

Exams

One midterm exam will be administered during the regular class (session time) period. The final exam will be administered at the location and within the time window determined and announced by the University.

I plan to have the midterm exam approximately during week 8 of the semester. The class between the end of a module and the midterm exam will be a mixture of review and (optionally, as time permits) material from the beginning of the next module. The midterm exam will cover all materials preceding the exam. The final exam is cumulative, i.e., in principle it covers the entire course material.

Final exam scheduling conflicts will be managed in strict adherence to university regulations. All students who have a final exam conflict must e-mail me a screenshot of their entire final exam schedule for the semester by the last day of classes, else all have to take the exam at the regularly scheduled time.

Open resources will be allowed during online exams, if such exams are approved by the university. During in-person exams, I will allow the usage of course materials specified as/when needed. Communication with any person other than your instructor is not permitted during exams, whether taken online or in-person.

GRADING POLICY

While I will rely on the assistance of graders to evaluate homework assignments, I plan to grade the exams myself (with grading assistance, if needed due to time constraints). This will help to assess fairly the individual effort and overall course-related knowledge of each student.

All assignments and exams will receive a score between 0 and 100. Your course grade will be based on the overall aggregate score, which combines the scores received on all class work with the following weights:

50% average homework score (based on all equally weighed assignments),
20% mid-term exam,
30% final exam.

The maximal aggregate score is 100. The following correspondence between aggregate scores and letter grades will be used:

$A \geq 90$, $B+ \geq 85$, $B \geq 80$, $C+ \geq 75$, $C \geq 70$, $D \geq 60$, $F < 60$.

In order to receive a passing grade, it is specifically required that you must pass the final exam with an exam score of at least 60. It is also rightly expected that your midterm and final exam performance closely matches the performance on homework assignments, else the validity of assignment-based performance becomes questionable. Low exam scores and apparent discrepancies between exam and assignment scores could negatively influence grades, at your instructor's discretion.

Rutgers University and I reserve the right to make changes to the above stated grade calculation method and grading policies, if deemed necessary.

All assignment and midterm exam scores will be communicated via the course site. Homework and exam grades will be posted on the "Grades" panel in Canvas. Feedback on homework performance will be available on Canvas. We will review the results of the midterm exam in class, one week after the midterm. For the final exam, solutions will be posted after all grading is completed. Exam solutions will be presented concisely, and should not be circulated.

Your final grade will be communicated using the grade submission system maintained by Rutgers University. The final grade is not subject to negotiation. Please do not expect grade adjustments based on personal reasons (such as scholarships with GPA requirements, etc.), also for fairness considering all course attendees.

There is no extra credit option to change grades after they have been posted, except at my discretion (e.g., in case of provable grading errors, or by request received from the university). If you believe that a grading error has been made, then submit your written argument within one week of the date when grades were posted, clarifying precisely the error made. If an error has been made indeed, then I will certainly correct it, and adjust your grade if needed. However, please be aware that if there are errors in your work which were not noticed earlier, then regrading could also lead to lowering your grade as well as to raising it.

STUDENT SUPPORT SERVICES

Accommodations for a disability: If you need accommodation for a certain disability, then please obtain a Letter of Accommodation from the Office of Disability Services (ODS) at Rutgers University. This Office provides student-centered and student-inclusive programming in compliance with the Americans with Disabilities Act of 1990, the Americans with Disabilities Act Amendments of 2008, Section 504 of the Rehabilitation Act of 1973, Section 508 of the Rehabilitation Act of 1998, and the New Jersey Law Against Discrimination. Students with special needs have to make proper arrangements with ODS before the course begins. In addition, all exams for students with special needs must be arranged with ODS in due time. Visit <https://ods.rutgers.edu> for more information.

Temporary condition or injury that is adversely affecting your ability to fully participate in course work: please submit a request via <https://temporaryconditions.rutgers.edu>.

Mental health services: please contact Rutgers University – New Brunswick Counseling and Psychological Services, <http://rhscaps.rutgers.edu/>.

Physical health services: please contact Rutgers University – New Brunswick Health Services, <http://health.rutgers.edu/>.

Gender or sex-based discrimination or harassment, including sexual assault or harassment, relationship violence, or stalking: please contact the Office for Violence Prevention and Victim Assistance, tel. (848) 932-1181. More information can be found at <http://vpva.rutgers.edu/>.

Rutgers University-New Brunswick concern and incident reports: <http://studentconduct.rutgers.edu/concern/>.

Unwanted pregnancy: the Office of Title IX and ADA Compliance is available to assist with any concerns or potential accommodations related to unwanted pregnancy. For further information, please visit <https://uec.rutgers.edu/programs/title-ix/coordinators/>.

If you are a military veteran or you are on active military duty, then you can obtain support through the Office of Veteran and Military Programs and Services, <http://veterans.rutgers.edu/>.

Rutgers University Student Legal Services: <http://rusls.rutgers.edu/>.

If you are experiencing difficulties in courses, due to using English as a second language, then contact Rutgers – New Brunswick Program in American Language Studies, esl.pals@english.rutgers.edu.

Additional academic assistance: please contact Rutgers University – New Brunswick Learning Center, <https://rlc.rutgers.edu/>.

Religious accommodations: please call Rutgers University – New Brunswick Dean of Students at (848) 932-2300 or email deanofstudents@echo.rutgers.edu.